CHAPTER 44

ANIMAL BEHAVIOR

Ducklings learn to follow their mother soon after hatching, an instinctive behavior called imprinting.

SECTION 1 ***Development of Behavior***

SECTION 2 ***Types of Animal Behavior***

BIOLOGY INTERACTIVE TUTOR

Unit 7—Ecosystem Dynamics
Topic 2

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DEVELOPMENT OF BEHAVIOR

A snake plays dead. A mouse presses a lever. A chimpanzee gathers termites on a stick. This section discusses how these and other behaviors are developed.

SECTION 1

OBJECTIVES

- **Identify** four questions asked by biologists who study behavior.
- **Describe** an example of an innate behavior.
- **Compare** four types of learned behavior.
- **Explain** how learning and genes can interact to affect behavior.

VOCABULARY

ethologist
behavior
innate behavior
fixed action pattern
learning
habituation
operant conditioning
classical conditioning
reasoning
imprinting
sensitive period

THE STUDY OF BEHAVIOR

Leaf-cutter ants cut sections of leaves with their sharp mouthparts and head back to the nest with their load of leaf bits. In the nest, other individuals tend and harvest the fungi that grow on the leaves as food for the colony. **Ethologists** (ee-THAHL-uh-JISTS), biologists who study behavior, seek to learn about such varied behaviors. **Behavior** is an action or series of actions performed by an organism, usually in response to a stimulus. In order to learn about behavior, ethologists ask questions about how and why a behavior occurs. For example, how do ants find their way to food and back to the colony? Why do ants share leaves with other colony members?

When considering an animal's behavior, ethologists ask four main questions: (1) What causes the behavior? What are the mechanisms that respond to stimuli? (2) What is the role of genes in the behavior; and how does it develop during an individual's lifetime? (3) What is the behavior's evolutionary history? (4) How does the behavior affect the organism's survival and reproduction?

Genes and Behavior

When studying behavior, ethologists often ask how much of an animal's behavior is determined by genetics and how much of the behavior is based on the unique developmental environment of the animal? Ethologists have studied bees to learn more about the role of genes in behavior. Some adult bees can detect which young in the hive have bacterial infections. These adult "hygienic" bees pull the diseased young from their cells and throw them out of the nest, as in Figure 44-1. In contrast, "nonhygienic" adult bees ignore diseased young.

American and Australian biologists mated hygienic queen bees to nonhygienic males and studied the inheritance pattern of this trait. They found that certain genes with set inheritance patterns control young-removal behaviors. This study showed that genes can underlie animal behavior. The triggers for the behavior, however, come from the environment. In this case, diseased young present in the hive trigger the removal behavior.

FIGURE 44-1
"Hygienic" bees carry diseased or dead young from the hive. Studies have shown that this behavior is highly heritable.

FIGURE 44-2

A male lion who has taken over a pride will often kill cubs fathered by rival males.

Natural Selection and Behavior

Ethologists have hypothesized that animals usually behave in ways that promote their survival and offspring production. Because genes control some behaviors, natural selection can affect genetic variation that involves behavioral genes. Lions present a good example of this principle. The males living in a particular pride (family group) father all of the cubs. Eventually new males come along and force out the previous males. After the new males take over, they often kill cubs fathered by the previous males, as shown in Figure 44-2.

Observing this, ethologists wondered how natural selection could favor killing young of the same species? Further observation revealed that females will not breed with males as long as those females are caring for young. If the infants die, however, the female will mate again. By killing the existing offspring, the new male is likely to produce more offspring than males who do not kill cubs. Ethologists hypothesize that natural selection has favored genes that cause male lions to kill cubs that are not their offspring. It is important to remember that this behavior is instinctive. It is neither conscious nor deliberately aimed at other males or their offspring.

INNATE BEHAVIOR

Innate behaviors, more commonly called instincts, are inherited actions that are performed effectively the first time without being taught. An orb spider, for example, builds her web the same way every time. There is very little variation in what she does, and all her female offspring will build their webs in a similar manner without being taught.

Fixed Action Pattern

FIGURE 44-3

This Eastern hognose snake *(Heterodon platyrhinos)* is "playing dead." The snake spreads its jaw, hisses, and rolls on its back.

A **fixed action pattern** is a rigid innate behavior that all members of a species perform the same way each time they perform it. Figure 44-3 shows an Eastern hognose snake displaying a fixed action pattern in response to a predator. The snake spreads its jaws, hisses, and rolls on its back when threatened. Individuals that perform this behavior are less likely to get eaten and more likely to reproduce than individuals that do not perform this behavior.

Fixed action patterns continue from start to finish without modification once an environmental stimulus triggers them. However, there are still factors that influence whether an animal will perform this behavior or not. For example, Greylag geese retrieve eggs that have rolled out of the nest the same way every time. They will also retrieve other objects that are similar in shape or size to an egg. However, only mother geese retrieve eggs that have rolled out of the nest, and they only perform this behavior between the time of egg laying and hatching.

LEARNED BEHAVIOR

Some aspects of behavior are influenced by genes, but to what degree can behaviors be modified by experience? Learned behaviors are actions that change with experience. **Learning** is the modification of a behavior based on experience. Learning can influence the expression of behaviors that are innate and also behaviors that are not innate. The study of learned behavior is central to much of ethology, and learning types can vary from simple to complex.

Habituation

The simplest type of learning, **habituation** (huh-bi-choo-AY-shuhn), occurs when an animal learns to ignore a frequent, harmless stimulus. For example, when an object passes overhead, a young gull chick tries to hide. As the chick grows older, and as parents, other common birds, or falling leaves pass over the chick's head without consequence, the youngster learns not to react. When a predatory bird flies over, however, the gull stops feeding to hide. Because the passing of a predator's shape is rare, the chicks never habituate to it. Habituation in gulls saves energy and allows feeding, yet preserves defenses for the rare emergency.

Operant Conditioning

A more complex type of learning occurs by trial and error. A dog, for example, learns to associate a cat's hiss and arched back with a painful scratch on the nose. When trial-and-error learning occurs under highly controlled conditions, it is called **operant** (AH-puhr-uhnt) **conditioning.** An animal associates some action or operation (the "operant") with a punishment or reward.

American psychologist B. F. Skinner investigated operant conditioning by placing a rat in a box with a lever, such as the one shown in Figure 44-4. As the rat explored the box, the rat eventually pressed the lever, which delivered a food pellet. After several accidental pressings, the rat learned to press the lever deliberately for food. Skinner thought that nearly any behavior could be "conditioned," or trained.

Further research by others, however, showed that although rats can easily learn to press a lever to receive food, they have trouble learning to press a lever to avoid electric shocks to their feet. Rats can learn quite quickly to avoid such foot shocks by jumping. Yet, it's much harder for them to learn to jump to get a food reward. These seeming contradictions do make sense: Rats in nature get food by manipulating objects with their hands, not their feet. Like all animals, rats most easily learn those things that are related to natural skills for survival and reproduction.

Quick Lab

Recognizing Learned Behavior

Materials small wads of paper towel (one moist; one dry), T maze made of five pieces of cardboard taped in a T shape inside a cardboard box, sow bug, blunt probe

Procedure

1. Place the moist paper in the left side of the T. Place the dry paper wad on the right side.
2. Place the sow bug at the bottom of the T. If it does not start to crawl, gently prod it with a blunt probe. Observe what the sow bug does when it reaches the T section.
3. Retrieve the sow bug. Perform as many trials as time allows. Record the results of each trial.

Analysis Summarize the sow bug's behavior. Determine if the sow bug modified its behavior through learning. Use evidence to support your answer.

FIGURE 44-4

A rat placed in the "Skinner box" shown here will learn to press a lever to obtain food. This behavior is an example of operant conditioning.

Classical Conditioning

Famed Russian biologist Ivan Pavlov studied another complex type of learning and published his results in 1903. Pavlov observed that dogs salivate at the sight and smell of meat. Was this response learned? To find out, he presented meat to a group of dogs. At the same time that the dogs received the meat, Pavlov would ring a bell. The dogs learned to associate the bell with a meat reward and eventually would salivate in response to the bell tone.

This kind of learning is called **classical conditioning.** The animal learns to associate a response with a predictive stimulus. The animal responds (salivation) after the natural stimulus (the meat) and learns to associate the natural stimulus with the predictive stimulus (the bell). This type of conditioning differs from operant conditioning in which the animal learns to respond (pushing the lever) *before* the reward appears (the food pellet).

Classical conditioning occurs in nature as well as in artificial conditions. For example, a crow learns to associate the sight of shiny, broken eggshells on the beach with the presence of newly hatched gull chicks and swoops down for a tasty meal. Advertising agencies capitalize on classical conditioning in humans by associating their product with positive imagery. They associate a certain car brand with financial success, or a certain cola with healthy good looks, all to trigger the desired response: purchase of their product.

Problem-Solving and Reasoning

A more complex type of learning is called *problem-solving learning.* Figure 44-5 shows an example of problem solving in which a chimpanzee uses a tool to get termites out of a nest. This behavior may be learned from watching a parent, may be a result of trial-and-error, or a combination of several learning mechanisms.

FIGURE 44-5

A chimpanzee will look for a stick and use it as a tool to retrieve termites from the nest for food.

One type of problem-solving, **reasoning,** involves the ability to solve a problem not previously encountered by the individual in a way that is not dictated by instinct. For example, if a chimpanzee enters a room with boxes scattered on the floor and sees a bunch of bananas tied to the ceiling, the animal will arrange the boxes to form a platform in order to retrieve the bananas.

In another example, researchers placed a jar containing a fish in a tank with an octopus. The octopus used its arms to unscrew the lid, removed the fish, and then discarded the jar and lid. This type of behavior cannot be considered instinctive, because boxes and jars are not in the evolutionary history of these species. The behavior occurred without trial-and-error, as if the animal used reasoning to develop an insight into how to solve the problem.

GENES, LEARNING, AND BEHAVIOR

Biologists have learned from studying bees and other organisms that genes can influence behavior. Some scientists have argued that most behaviors are genetically programmed because different individuals in the same species act in the same ways. Other scientists assert that behaviors are shaped by an animal's experiences. Most ethologists today have come to agree that animal behavior, especially complex behavior such as that seen in primates, is affected both by genes and by experience.

Imprinting

One class of behavior that is determined by both genes and learning is called imprinting. **Imprinting** is a form of learning in which a young animal forms permanent associations with its environment. The most common imprinting occurs when new-born animals learn to identify a mother figure. Nobel Prize-winning ethologist Konrad Lorenz studied how geese come to identify their mothers and follow them to ponds to feed. Lorenz found that goslings follow the first large object they see moving away from the nest. The goslings would follow wagons, boxes, balloons, and even Lorenz himself, as seen in Figure 44-6.

Another example is found in sea turtles. Sea turtles imprint on characteristics of the beach where they hatch. Years later they are able to find their way back to the same beach to breed.

Imprinting occurs during a specific phase in an animal's development, called a **sensitive period.** During this time, certain types of learning take place that are later very difficult to change. For example, it is much easier for young children to learn multiple languages. This is much more difficult later in life. Scientists hypothesize that this change in the ability to learn as young animals mature is related to genes that control processes of development.

FIGURE 44-6

These young geese are following Nobel Prize winner Konrad Lorenz. Lorenz cared for the goslings the first day or so after they hatched, and the goslings imprinted on him.

SECTION 1 REVIEW

1. What are four questions that an ethologist might ask when studying behavior?
2. How is it possible for natural selection to affect an innate behavior?
3. Describe four types of learned behavior.
4. Explain the difference between the learning styles involved with Skinner's box and Pavlov's dogs.
5. Why is imprinting an example of interaction between learned and innate behavior?

CRITICAL THINKING

6. **Applying Information** If you trained bears for a stage show, which principles of behavior would you use?
7. **Forming Reasoned Opinions** A 6'10" man has a 5-year-old son. When the son goes through a doorway, he lowers his head as the father does. Do you think this behavior is likely to be learned or innate? Why?
8. **Justifying Conclusions** What do you think is the adaptive value of imprinting? Explain.

Science in Action

Does Sonar Cause Whale Strandings?

Every year, thousands of whales and dolphins strand themselves on beaches and often die. Scientists think that the whales may strand themselves individually or in groups for a variety of reasons. In recent years, beaked whales, which are not usually known for this behavior, have been beaching themselves with alarming frequency. Are human actions related to this increase?

Kenneth Balcomb

HYPOTHESIS: Sonar Causes Whale Beachings

The ocean is filled with sounds generated during human activities: shipping, fishing, oil drilling, oceanography research, and military operations. The U.S. Navy, for instance, uses a sonar system to detect submarine movements. The blasts of low frequency sound used by the military are so loud they can travel hundreds of miles at decibel levels equivalent to the sound of jet engines.

In March of 2000, 16 whales beached themselves on the Bahamas within 24 hours of a Naval sonar test. Six died. Kenneth Balcomb heads the Bahamas Marine Mammal Survey research station. Balcomb was aware of several past incidents in which mass strandings occurred around the time of naval maneuvers. It was unknown whether these events were connected. The closeness and timing of the Naval testing in the Bahamas seemed to suggest a sound-related stranding. Balcomb and co-researchers hypothesized that the loud sonar damaged the whales' hearing and in some way led to the beachings.

METHODS: Autopsy Whales and Analyze Tissue

Balcomb quickly removed the heads of two dead whales, froze the 200-pound specimens, and had them flown to the Woods Hole Oceanographic Institute in Massachusetts. There, he and others performed CT scans and microanalysis of inner ear and brain tissues.

Scientists are currently studying why whales are beaching themselves at increasing rates. Members of the Marine Animal Rescue Society are performing an autopsy on this beached whale.

RESULTS: Tissues Show Signs of Damage

The whales that were examined all showed similar lesions, including internal bleeding, known as hemorrhaging, in the acoustic regions of the cranium and mandible and in tissues next to airspaces around the ear bones. One specimen that was examined by ultra high-resolution computerized tomography showed a brain hemorrhage. In addition, dissection of this same specimen showed lung hemorrhage and laryngeal hemorrhage.

CONCLUSION: Evidence Supports Sonar-Induced Tissue Damage and Death

Based on the results of specimen examination, the National Marine Fisheries Service and the Navy came to the same conclusion: the injuries were all consistent with an intense acoustic or pressure event.

In September of 2002, 14 more whales stranded themselves in the Canary Islands following military maneuvers by NATO using sonar. Paul Jepson of the Zoological Society of London and colleagues found that the whales suffered tissue and organ damage similar to that found in the whales beached in the Bahamas.

In June 2003, a federal judge-magistrate in San Francisco ruled that the Navy must limit its plans for low-frequency sonar exercises. The Navy is currently working to establish those limits.

REVIEW

1. What evidence supports Balcomb's hypothesis?
2. Evaluate the conclusion reached by Balcomb. Is it a valid conclusion? Explain your reasoning.
3. **Critical Thinking** Are there situations in which the use of sonar by the military is justified? Explain.

SECTION 2

TYPES OF ANIMAL BEHAVIOR

Animals all need to obtain food, find places to live, protect themselves, attract mates, reproduce, and care for young. This section discusses types of behaviors that help animals accomplish these actions.

OBJECTIVES

- **Discuss** the optimality hypothesis and feeding behavior.
- **List** three types of competitive behavior.
- **Describe** three different types of reproductive behavior.
- **Name** five kinds of communication.
- **Identify** costs and benefits of social behavior.
- **Describe** four types of cyclic behavior.

VOCABULARY

optimality hypothesis
aggressive behavior
territory
dominance hierarchy
courtship
communication
aposematic coloration
mimicry
pheromone
social behavior
circadian rhythm
hibernation
migration

FEEDING BEHAVIOR

Most animals spend the majority of their waking hours searching for, catching, or eating their food. How do they balance the energy they expend versus the energy they gain? One possible explanation is described by the **optimality hypothesis,** the idea that animals tend to behave in a way that maximizes food gathering while minimizing effort and exposure to predators.

For example, researchers have watched crows choose a large whelk (a snail-like mollusk) fly with it to a height of about 5 m (16 ft), and then drop it onto a rock. If the shell breaks, the crow eats the whelk. If the shell fails to break, the crow picks it up and drops it again. The optimality hypothesis would predict that dropping a whelk a second time is more likely to provide a meal than is searching for another large whelk. Experiments confirm that crow behavior optimizes nutrition versus effort expended.

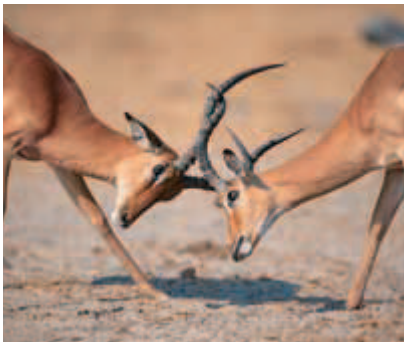
COMPETITIVE BEHAVIOR

Each species needs a place to live that provides shelter from bad weather, adequate food and water, and access to mates. Because such resources are limited, competition is often the result. Competition between animals of the same species can be seen in several types of behavior.

Aggressive Behavior

Physical conflict or threatening behavior between animals is called **aggressive behavior.** This type of behavior includes displays and contests of strength that determine which individual is larger or stronger. The male impalas in Figure 44-7 display aggressive behavior when competing for mates. Most often, these contests result in one animal "surrendering" to the other. Usually, the larger or healthier male wins, and both leave unhurt.

FIGURE 44-7
Male impalas defend their territories against intrusion by other males.



Territorial Behavior

One way to ensure that an animal is able to obtain sufficient resources for itself, its mate, and its offspring is for the animal to select and establish a territory. A **territory** is an area that an animal or a group of animals occupies and defends from other members of the same species. An animal establishes a territory in many ways, including marking the boundaries with urine or visual cues, and claiming an area with vocal signals. Territorial animals will threaten or attack intruders.

The male bowerbird shown in Figure 44-8 has established a small territory which includes his nest and the area around it. He has marked the territory by building and decorating a bower and will defend it from other males. Animals may be territorial under certain circumstances. For example, the bowerbird only builds and defends his territory during breeding season. Natural selection can reinforce territorial behavior. When animals space themselves out, they do not compete for the same resources. This behavior increases the likelihood that the young of territorial animals will survive and inherit traits that promote territoriality.

Dominance Hierarchies

Competition can lead to a clear ranking of individuals within the group, from most dominant to most subordinate. This type of ranking, called a **dominance hierarchy** (HIE-rahr-kee), reduces the need for competition and aggressive behavior as subordinates learn to submit to avoid conflict. One example of a dominance hierarchy is that formed by chickens. The dominant chicken can peck all other chickens. The most subordinate chicken gets pecked by all other chickens in the group. It is from this behavior in chickens that the term "pecking order" is derived.

FIGURE 44-8

Male bowerbirds *(Amblyornis inornatus)* build elaborate nests of various shapes and with different decorations. Females choose a mate based on his bower-building abilities.

REPRODUCTIVE BEHAVIOR

Elaborate behaviors have evolved around the process of reproduction in many animals. These behaviors often differ between males and females. Differences generally center around attracting or competing for a mate. Reproductive behaviors may help animals recognize members of the same species, or members of the opposite sex. They may also be indicators of good health.

Sexual Selection

Animals generally choose mates based on certain traits or behaviors. This tendency creates a process called *sexual selection.* Traits or behaviors that increase an individual's ability to acquire a mate will appear with increased frequency in a population. The female bowerbird in Figure 44-8 chose this male based on his ability to build and decorate an attractive bower. His offspring will probably build bowers in a similar way.

Another means of attracting a mate involves certain behaviors, called **courtship.** In some species, courtship can include a complex series of behaviors called *rituals*. Courtship rituals are instinctive behaviors that are performed the same way by all members of a population and that may help animals identify receptive mates of the same species. Most courtship rituals consist of specific signals and responses that indicate willingness to mate.

Mating Systems

Mating systems increase the likelihood that young will survive. Male polygamy (more than one female), monogamy, and female polygamy (more than one male) are reproductive strategies that are determined primarily by the amount and type of parental care required by the young. Monogamy is favored in situations in which there are advantages to both parents raising the young. In birds, for example, it would be difficult for one parent to protect the nest and the hatchlings while also providing enough food for the young. This type of situation may explain why birds tend to be monogamous.

Word Roots and Origins

monogamy

from the Greek *mono,* meaning "one," and *gamus,* meaning "marriage"

Parental Behavior

Parental investment is the time and energy an individual must spend to produce and nurture offspring. The benefit of parental care is that it increases the likelihood that young will survive to adulthood. The costs are that parental care can generally only be provided for a small number of young because of the large energy investment by the parent. Usually, females invest more in parental care than males do. In mammals like the whales in Figure 44-9, the female carries the young within her body during development, and after birth the young must nurse. In some species, the male provides the majority of parental investment. Male seahorses, for example, carry the eggs until they hatch.

FIGURE 44-9

Whales provide extensive parental care for their young. Baby mammals are often born rather helpless and learn about their environments from parents.

FIGURE 44-10

Ants use chemical communication in the form of a pheromone trail, which other ants will follow. The ants above are following a trail on a leaf.

COMMUNICATION

Ant pheromones, bird songs, whale song; these behaviors are all examples of **communication,** signals produced by one animal that result in some type of response in another. There are many ways animals can communicate, including sight, sound, chemicals, touch, and possibly even language.

Sight and Sound

Species living in open environments often use visual signals to provide rapid communication. Behavioral displays communicate within and between species. Bright colors often serve as a warning that an animal is poisonous. This is called **aposematic** (A-poh-suh-MA-tic) **coloration.** After several encounters, predators learn to associate this color or pattern with a bad experience. Some animals gain protection by looking like a dangerous animal. This strategy is called **mimicry.**

Nocturnal animals, and animals in habitats with restricted visibility, often use sound to communicate. Bullfrogs and crickets, for example, use sound to attract a mate. Elephants communicate at a frequency that is too low for humans to hear.

Chemicals

Chemical communication can convey information over greater distance and time than can communication by sight or sound. Some animals release chemicals called **pheromones** (FER-uh-mohns) that cause individuals of the same species to react in a predictable way. For example, ants leave a pheromone trail that other individuals can follow, as shown in Figure 44-10. Female moths release a pheromone that attracts a male of her species from miles away.

FIGURE 44-11

The blurred image in the center of the hive is a bee vigorously performing a waggle dance. Her sisters are receiving information about the direction and distance of a food source in part by touch communication.

Touch

Species that inhabit dark hives or dens often communicate by touch in addition to using sound or chemicals. Honeybees use a display that includes sight, touch, and sound, shown in Figure 44-11, to communicate the direction and distance to a food source.

Language

Most scientists have regarded language as a uniquely human behavior. In order for communication to be considered language, there are certain criteria that must be met. Among these are *phonemes* (sounds that can be combined to form words), *productivity* (many combinations of phonemes to produce different meanings), and *grammar* (rules for combining words that affect the meaning). Most animal communication lacks at least one of the characteristics of true language. Although animals do not use language systems for communication in the wild, it is possible that they can learn to use them. Research on language is being done with gorillas, chimpanzees, bonobos, parrots, dogs, and dolphins.

SOCIAL BEHAVIOR

Social behavior can be defined as any kind of interaction between two or more animals, usually of the same species. Some species, like the bonobos in Figure 44-12, spend the majority of their lives in social groups.

FIGURE 44-12
Bonobos are a species of ape closely related to chimpanzees. Bonobos have a highly complex and unusually peaceful social system.

Social Groups

Social groups have evolved in the animal kingdom because there are benefits to living in a group. These benefits can include protection from predators and more success in foraging. For example, fish on the outer edges of a school assume most of the danger of predation. The fish swimming on the edges shift constantly, so most individuals are not exposed to danger for a long time. Lions hunting cooperatively can bring down large prey much more efficiently than lions hunting alone.

There are also disadvantages to living in a social group. For example, there is often increased competition for food, mates, and other resources. The risk of spreading disease is also higher within a social group than it would be among a population of nonsocial animals. One species that exemplifies both the benefits and disadvantages of social groups is the blue-gill sunfish. During mating season, bluegills nest close together. The larger number of individuals helps provide protection against predators. However, disadvantages include competition during courtship, theft of eggs by nonbreeding males, and possibly transmission of disease.

Altruism

Occasionally, one member of a social group acts in a way that benefits other members of the group while putting the individual at a disadvantage. This type of behavior is called *altruism* (AL-troo-ism). One example of altruism can be seen in the ground squirrel found in North America. These animals live in large colonies. If one member of the colony sees a predator, it will give a high-pitched alarm call, as shown in Figure 44-13. This call warns other members of the colony to hide while putting the animal that calls at risk.

FIGURE 44-13
A ground squirrel gives a piercing warning call that signals the presence of a predator.

Another example of altruism occurs in animal societies in which the workers are sterile. Bees, ants, termites, and naked mole rats are all examples of animals that live in this type of society. Usually, members of a society are related to each other and share a large proportion of their genes. Therefore, helping a relative survive increases the chance that the genes an individual shares with that relative will be passed to the next generation. This type of natural selection is called *kin selection*.

Word Roots and Origins

circadian

From the Latin *circa,* meaning "about," and the Latin *dian,* meaning "day"

CYCLIC BEHAVIOR

Animals display a variety of cyclic behaviors that are synchronized with changes in their environment. These behaviors generally develop as a result of temperature changes, variations in availability of food, or likelihood of predation.

Biological Rhythms

During the day, gorillas are busy foraging but during the night, they rest. A daily biological cycle is called a **circadian** (suhr-KAY-dee-uhn) **rhythm.** Predators have evolved biological rhythms in response to the activity of their prey. For example, mice are active at night, and as a result, owls are also active at night.

Many marine animals that live along the shore have biological cycles related to the tides. Tidal cycles are also called *lunar cycles* because the tide is determined by the phases of the moon. For example, fiddler crabs on the eastern coast of the United States emerge from their burrows at every low tide (twice every 24 hours).

There are also annual biological cycles. Some animals go into a period of inactivity and lowered body temperature during the winter when food is scarce. This type of behavior is called **hibernation.** Some hibernating animals, such as ground squirrels, drop their body temperature to a few degrees above freezing and do not wake for weeks at a time.

FIGURE 44-14

Monarch butterflies migrate hundreds of miles to spend their winters in central Mexico.

Migratory Behavior

Migration is a periodic group movement that is characteristic of a population or species. There are many types of migration. The monarch butterflies, shown in Figure 44-14, migrate hundreds of miles each year to winter in Mexico. Salmon migrate from their ocean habitat into streams to breed, then back to the ocean. Migration is exhausting and risky yet it allows animals to find habitats with plentiful seasonal foods and provides nesting sites safe from predators.

SECTION 2 REVIEW

1. Summarize the optimality hypothesis.
2. Give an example of three types of competitive behavior seen in animals.
3. How can sexual selection affect reproductive behaviors?
4. Describe an example of four types of communication used by animals.
5. Identify advantages and disadvantages of living in a social group.
6. Describe four types of cyclic behavior.

CRITICAL THINKING

7. **Applying Information** Male widowbirds have very long tails. What might be some advantages and disadvantages of having long tails?
8. **Forming Hypotheses** If a species of squirrel eats only soft acorns, what would the optimality hypothesis predict about the energy required to open hard acorns?
9. **Analyzing Information** How does defending a territory benefit an animal when aggressive competition may cause physical injury?

CHAPTER HIGHLIGHTS

SECTION 1 Development of Behavior

- Behavior is an action or series of actions performed by an animal in response to a stimulus.
- Ethologists seek to learn the cause, genetic development, evolutionary history, and reproductive advantage of a behavior.
- Innate behaviors are instinctive behaviors that do not vary despite an animal's environment or experience. A fixed action pattern (FAP) is an example of an innate behavior.
- Learned behavior is a behavior that is based on experience.
- The four types of learned behavior are habituation, operant conditioning, classical conditioning, and problem solving.
- In some cases, such as with imprinting, genes and learning can interact to affect behavior.

Vocabulary

ethologist (p. 887)
behavior (p. 887)
innate behavior (p. 888)
fixed action pattern (p. 888)
learning (p. 889)
habituation (p. 889)
operant conditioning (p. 889)
classical conditioning (p. 890)
reasoning (p. 890)
imprinting (p. 891)
sensitive period (p. 891)

SECTION 2 Types of Animal Behavior

- According to the optimality hypothesis, animals tend to maximize food gathering while minimizing effort and exposure to predators.
- Three types of competitive behavior include aggressive behavior, territorial behavior, and formation of dominance hierarchies.
- Sexual selection happens when certain mates are chosen over others based on a certain trait or set of traits.
- Animals show variation in mating systems and parental care, based on the amount of care the young require at birth.
- Five forms of communication are visual, sound, chemical, touch, and language.
- The benefits of social behavior include predator protection and successful foraging. The costs of social behavior include increased competition and risk of spreading disease.
- Some behaviors occur in synchrony with cyclical changes in the environment. These cyclic behaviors include circadian rhythms, lunar cycles, hibernation, and migration.

Vocabulary

optimality hypothesis (p. 893)
aggressive behavior (p. 893)
territory (p. 894)
dominance hierarchy (p. 894)
courtship (p. 895)
communication (p. 896)
aposematic coloration (p. 896)
mimicry (p. 896)
pheromone (p. 896)
social behavior (p. 897)
circadian rhythm (p. 898)
hibernation (p. 898)
migration (p. 898)

CHAPTER REVIEW

USING VOCABULARY

1. For each pair of terms, explain how the meanings of the terms differ.
   a. *innate behavior* and *learned behavior*
   b. *classical conditioning* and *operant conditioning*
   c. *hibernation* and *migration*
2. Explain the relationship between *competitive behavior* and *dominance hierarchy*.
3. Use the following terms in the same sentence: *social behavior, altruism,* and *kin selection.*
4. **Word Roots and Origins** The word *ethology* comes from the Greek *etho,* which means "habit" and the suffix *ology* which means "the study of." Using this information, explain why the term *ethology* is a good name for the study of behavior.

UNDERSTANDING KEY CONCEPTS

5. **Identify** four questions an ethologist would ask when studying a behavior.
6. **Explain** whether nest building in bowerbirds is innate or learned.
7. **Name** the behavior a mother goose is displaying when she rolls a baseball back to her nest.
8. **List** examples of each of the four types of learning.
9. **Describe** the learning experiment involving rats and Skinner's box.
10. **Describe** the experiments of Konrad Lorenz.
11. **Explain** the reason a dog tied to a tree would probably wrap the rope around the trunk while a chimpanzee would not.
12. **Identify** how genes and learning are involved in imprinting.
13. **State** the hypothesis that explains why a cheetah quits chasing prey after 100 yards.
14. **Describe** three types of competitive behavior.
15. **Compare** the costs versus the benefits of territoriality for impalas.
16. **Name** the type of selection that would result in peacocks with larger tails.
17. **Explain** the relationship between parental care and the type of mating system found in a species.
18. **Identify** an example for each of the four different types of communication found in animals.
19. **Identify** the types of communication that are displayed during a waggle dance.
20. **Relate** the costs and benefits of social behavior to life in a prairie dog colony.
21. **Explain** the biological reason for each of the four types of cyclic behaviors.
22. **Describe** the biological cycle that explains jet lag in people who travel across time zones.
23. **CONCEPT MAPPING** Use the following terms to create a concept map that describes animal behavior: *behavior, stimulus, innate behavior, fixed action pattern, learned behavior, conditioning, reasoning, imprinting,* and *sexual selection*.

CRITICAL THINKING

24. **Analyzing Information** Imagine that a mutation resulted in an animal that could not experience habituation. Explain the effect on the individual and how natural selection might act on this mutation.
25. **Forming Reasoned Opinions** A friend insists that animals can only communicate with members of their own species. Is this true? Explain and support your opinion.
26. **Critiquing a Scientific Explanation** Biologists cut the tails of male widowbirds and found that they mated with only half as many females as males with uncut tails. Should the scientists conclude that female widowbirds prefer long tails? Why or why not?
27. **Recognizing Relationships** In many bird species, the male is more brightly colored than the female. Explain how natural selection and sexual selection might result in these characteristics.
28. **Interpreting Graphics** Identify the type of behavior displayed in the following image. Explain how natural selection might play a role in developing this behavior.

Standardized Test Preparation

DIRECTIONS: Choose the letter of the answer choice that best answers the question.

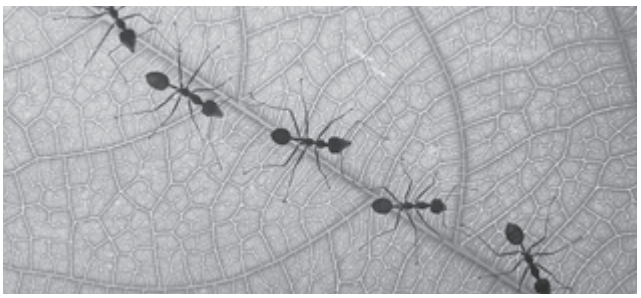
1. An orb spider builds her web in exactly the same way every time. This is an example of what type of behavior?
   A. random behavior
   B. learned behavior
   C. abnormal behavior
   D. fixed action pattern behavior

2. What type of learning can only occur during a specific period early in an animal's life?
   F. reasoning
   G. assuming
   H. imprinting
   J. conditioning

3. A male lion kills all the young cubs of rival males. The genes of which of the following would be favored by this behavior?
   A. the pride
   B. the female
   C. the male lion
   D. the male lion's siblings

4. Which of the following represents classical conditioning?
   F. rats feeding in Skinner boxes
   G. a dog salivating at the sound of a bell
   H. a male bullfrog croaking loudly in a pond
   J. a primate giving a warning signal to troop members

INTERPRETING GRAPHICS: The photo below shows ants following a pheromone trail. Use the photo to answer the questions that follow.



5. The behavior of the ants is most likely to be what type of behavior?
   A. innate
   B. learned
   C. habituation
   D. classical conditioning

6. What type of communication are the ants using?
   F. visual communication
   G. sound communication
   H. communication by touch
   J. chemical communication

DIRECTIONS: Complete the following analogy.

7. aggression : competitive behavior :: altruism :
   A. conditioning
   B. social behavior
   C. parental behavior
   D. fixed action pattern behavior

INTERPRETING GRAPHICS: The photo below shows Konrad Lorenz with goslings that imprinted on him. Use the photo to answer the question that follows.

8. What is the most likely advantage to the behavior illustrated above?
   F. Goslings who follow buckets are more successful in finding food.
   G. Adult wild geese that associate with humans reproduce more successfully.
   H. Traveling in single file is the most successful way for geese to avoid predators.
   J. Goslings who follow their mother are more likely to find food and safety from predators.

SHORT RESPONSE

A male lion entering a pride kills all the young cubs.

What are the benefits of the male's behavior?

EXTENDED RESPONSE

You have been hired to invent a humane method for fighting household ants. Use the behavior pictured in Questions 5–6 to accomplish this job and explain your invention.

Test TIP Do not try to rush to finish a test. Many mistakes are made as a result of carelessness.

Studying Nonverbal Communication

OBJECTIVES

- Recognize that posture is a type of nonverbal communication.
- Observe how human posture changes during a conversation.
- Determine the relationship of gender to the postural changes that occur during a conversation.

PROCESS SKILLS

- observing
- analyzing
- graphing
- collecting data

MATERIALS

- paper
- pencil
- stopwatch or clock with a second hand

Background

People communicate nonverbally with their **posture,** or body position. The position of the body while standing is called the **stance.** In an **equal stance,** the body weight is supported equally by both legs. In an **unequal stance,** more weight is supported by one leg than by the other. In this lab, you will observe and analyze how stance changes during conversations between pairs of people who are standing.

1. Write a definition for each boldface term in the paragraph above.
2. Make a data table similar to the one on the next page. The sample data entered in row 1 show how to enter data. Do not copy these data.
3. Based on the objectives for this lab, write a question you would like to explore about nonverbal communication.

PART A Observing Behavior

1. Work in a group of two or three to observe conversations between pairs of people. Each conversation must last between 45 seconds and 5 minutes. One person in your group should be the timekeeper and the other group members should record data. Be sure that your subjects are unaware they are being observed.
2. Observe at least three conversations. Record the genders of the two participants in each conversation and the gender of the one person whose posture you observe. Be sure that the timekeeper accurately clocks the passage of each 15-second interval.
3. For each 15-second interval, record all of the changes in stance by the person you are observing. For example, note every time your subject shifts from an equal stance to an unequal stance, or vice versa.

To record the stance simply, you may write *E* to identify an equal stance and *U* to identify an unequal stance.

4. If the subject assumes an unequal stance, also record the number of weight shifts from one foot to the other. Indicate a weight shift simply by writing *W*.
5. When a conversation ends, write down whether the pair departed together or separately. To record this, write *T* to indicate departing together, or *S* to indicate departing separately.
6. After you have completed each observation, tally the total number of weight shifts within each 15-second block. **IMPORTANT!** Retain data only for conversations that last 45 seconds. If a conversation ends before you have collected data for 45 seconds, observe another conversation.

PART B Analyzing Behavior

7. After all observations have been completed, combine the data from all of the groups in your class. Analyze the data, without regard to gender.
   a. Determine the most common stance during the first 15 seconds of a conversation, the middle 15 seconds, and the last 15 seconds. Make a bar graph to summarize the class data.
   b. Find the average number of weight shifts in the beginning, middle, and end intervals. Make a bar graph to summarize the class data.
8. Repeat step 7, but analyze the data according to gender this time.
9. Compile the data and make bar graphs for each of the following: males talking with a male, males talking with a female, females talking with a male, and females talking with a female. Compare these graphs with the ones you made in step 7.

Analysis and Conclusions

1. Which stance was used most often during a conversation?
2. Based on your observations, which behavior most often signals that a conversation is about to end: stance change or weight shift?
3. Do males and females differ in their departure signals? If so, describe the differences you observed. Justify your conclusion.
4. What do you think might be an adaptive significance of a departure signal?
5. What other behaviors did you observe that were forms of nonverbal communication? Propose a reason for each type of behavior. Justify your answer.

Further Inquiry

Write a new question about animal behavior. Propose an experiment that you could use to answer your question. Identify the animal that you think would be best for your study and justify your reason for choosing it.

TABLE 1 *OBSERVING NONVERBAL COMMUNICATION*

	Gender		15-s intervals		
Pairs	**Involved**	**Observed**	**15 s**	**30 s**	**45 s**
1	**F, M**	**M**	**U, W**	**E**	**E**
2					
3					